TITLE: **Battery-free Wireless Temperature Sensor**

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1. ABSTRACT

Program Introduction: Rationale and Objective

The objective of the proposed research program is to conduct research into battery-free wireless sensing mechanism in order to develop novel passive wireless sensors and sensor network for physical and chemical parameter monitoring in a harsh environment. High temperature capacitive sensing materials with dielectric response to physical and chemical exposure and inductor-capacitor based passive wireless sensing platform will be developed and characterized. Multilayer Ceramic Integrated Circuit (MCIC) Technology and ceramic Green Tape™ material system are proposed to incorporate with the capacitive sensing materials to ensure sensors operation in various harsh environments. The measured parameter is frequency-encoded that is wirelessly monitored by a reader. Energy needed for the sensor operation is provided by inductive power. Thus, no wires or batteries are attached to the sensor unit. The hybrid Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) protocol will be adopted to build a wireless sensor network, and associated multi-coils swept frequency reader electronics will be developed.

Accomplishments Achieved During the Current Period of Performance

During the current period of performance, March 2007 – March 2008, overall structure of battery-free wireless temperature sensor has been designed and a group of critical design parameters, which determine the sensor design and its performance, were identified. These parameters include sensor geometry parameters, material sensing properties and its electric property parameters and sensor performance parameters. First order capacitive sensing element model and inductor coil model have been developed for detailed design of the proposed wireless temperature sensor. Based on the temperature sensing area, diameter of inductor coil and dielectric property of a temperature sensing material to be developed, resonant frequency of the temperature sensor can be determined. Once we have the temperature sensing material, fabrication processing and experimental setup ready, the proposed wireless temperature sensor geometrical design and desired operating frequency range with test temperature sensing range can be specified.

Plans for the Remaining Period of Performance

The work planned for the remaining months of this research program include the following tasks:

- Incorporate a temperature sensitive material with the wireless sensing platform to realize battery-free wireless temperature sensing functionality in a harsh environment;
- Design and implement a capacitance-based wireless pressure and gas sensors for various passive wireless sensing applications;
- Fabricate two prototypes for each proposed wireless sensor by using DuPont ceramic Green Tape™ material system and Multilayer Ceramic Integrated Circuit (MCIC) Technology;
- Sensor reader design and associated electronics development to demonstrate a complete passive wireless sensing system;
- Employ hybrid Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) protocol to build up a passive wireless sensor network;
- Characterize these wireless sensors and the wireless sensor network in an elevated temperature environment up to 800 °C.

2. LIST OF PUBLISHED JOURNAL ARTICLES, COMPLETED PRESENTATIONS AND STUDENTS RECEIVING SUPPORT FROM THE GRANT

Conference Presentations

1. Integrated Passive Wireless Temperature Sensors For Bearing Health Monitoring, presented at the 3rd Airport Seminar, Dresden, Germany, on November 7, 2007
2. "Passive and Wireless Sensors Research at UPRM", presented at the Taiyuan University of Technology, China, January 2, 2008.

List of Journal articles under preparation:

1. F. Andrés Bejarano, Jia Yi, and Frederick Just, "Crack Identification of a Rotating Shaft With Integrated Wireless Sensors**,** to be submitted.
3. Ya Wang and Yi Jia, "Performance Analysis of a Passive Wireless Temperature Sensor", to be submitted
4. Yi Jia, Henning Heuer, Susanne Hillmann, Norbert Meyendorf, "Stray Capacitances of Air-Cored Eddy Current Sensor", to be submitted.

Students Supported Under this Grant

1. F. Andrés Bejarano, graduate student in the Department of Mechanical Enginering, UPRM
2. Ya Wang, graduate student in the Department of Mechanical Enginering, UPRM
3. Jose Villalobos, graduate student in the Department of Mechanical Enginering, UPRM
4. Sulabel Sánchez, undergraduate student in the Department of Electrical Enginering, UPRM